(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 239 506 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
22.07.2015 Bulletin 2015/30

(51) Int Cl.:
F23R 3/28 (2006.01) *F23R 3/10* (2006.01)
F23D 14/62 (2006.01)

(21) Application number: **10152193.8**

(22) Date of filing: **29.01.2010**

(54) **Premixing direct injector**

Vormischende Direkteinspritzdüse

Injecteur direct de prémélange

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR

(30) Priority: **03.04.2009 US 417896**

(43) Date of publication of application:
13.10.2010 Bulletin 2010/41

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Printed by Jouve, 75001 PARIS (FR)

Description

BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates to fuel injectors for turbine engines.

[0002] Turbine engines such as, for example, gas turbine engines may operate using a number of different types of fuels. The use of natural gas to power turbine engines has led to a reduction in the emissions of turbine engines and increased efficiency. Other fuels, such as, for example hydrogen (H2) and mixtures of hydrogen and nitrogen offer further reductions of emissions and greater efficiency.

[0003] Hydrogen fuels often have a higher reactivity than natural gas fuels, causing hydrogen fuel to combust more easily. Thus, fuel nozzles designed for use with natural gas fuels may not be fully compatible for use with fuels having a higher reactivity.

[0004] US 4100733 describes a fuel supply means comprising a cylindrical member forming the outer wall of the supply means, an upstream plate-like member affixed to the cylindrical outer wall and which forms the upstream wall of the supply means and a downstream plate-like member which is affixed to the cylindrical outer wall at a location spaced axially from the upstream plate-like member forming a fuel chamber therebetween. A divider is spaced axially between the upstream and downstream plate-like members to form a primary section and an axially adjacent, secondary section within the fuel chamber. The fuel supply means includes means for directing fuel to the primary and secondary sections of the fuel chamber and a plurality of open ended, mixing tubes which penetrate the upstream and downstream plate-like members and are adapted to flow air therethrough across the fuel supply means. Each tube has at least one orifice through which fuel is flowable from the primary section for mixing with the through flowing air.

BRIEF DESCRIPTION OF THE INVENTION

[0005] The invention resides in a fuel injection nozzle as defined in the appended claims.

[0006] These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWING

[0007] The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features, and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective, partially cut-away view of an exemplary embodiment of a portion of a Premixing Direct Injector (PDI) injector nozzle.

FIG. 2 is a side cut-away view of a portion of the PDI injector nozzle of FIG. 1.

FIG. 3 is perspective, partially cut-away view of a portion of the PDI injector nozzle of FIG. 1.

The detailed description explains embodiments of the invention, together with advantages and features, by way of example with reference to the drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0008] Gas turbine engines may operate using a variety of fuels. The use of natural gas, for example, offers savings in fuel cost and decreases carbon and other undesirable emissions. Some gas turbine engines inject the fuel into a combustor where the fuel mixes with an air stream and is ignited. One disadvantage of mixing the fuel and air in the combustor is that the mixture may not be uniformly mixed prior to combustion. The combustion of a non-uniform fuel air mixture may result in some portions of the mixture combusting at higher temperatures than other portions of the mixture. The higher temperatures are undesirable because the chemical reaction at the higher temperatures may result in the emission of undesirable pollutants.

[0009] One method for overcoming the non-uniform mixture of gasses in the combustor includes mixing the fuel and air prior to injecting the mixture into the combustor. The method is performed by, for example, a premixing direct injection (PDI) injector fuel nozzle. The use of a PDI injector nozzle to mix, for example, natural gas and air allows a uniform mixture of fuel and air to be injected into the combustor prior to ignition of the mixture. Hydrogen gas (H2) and mixtures of hydrogen and, for example, nitrogen gas used as fuel offer a further reduction in pollutants emitted from the gas turbine. In gas turbine engines, it is undesirable for combustion to occur in the injector, since the injector is designed to operate in temperatures below combustion temperatures. Rather, a PDI injector is intended to mix the relatively cool fuel and air, and emit the mixture into the combustor where the mixture is combusted.

[0010] FIG. 1 illustrates a perspective, partially cut-away view of an exemplary embodiment of a portion of a PDI injector nozzle 100 (injector). The injector 100 includes a body member 102 having an upstream wall 104 and a downstream wall 106. A baffle member 108 is disposed in the body member 102, and defines an upstream chamber 110 and a downstream chamber 112. A plurality of mixing tubes 114 is disposed in the body member 102. The mixing tubes 114 include inlets 116 communicative between the upstream chamber 110 and an inner surface of the mixing tubes 114.

[0011] In operation, air flows along a path indicated by the arrow 101 through a shroud 118. The air enters the mixing tubes 114 via apertures in the upstream wall 104. A fuel, such as, for example, hydrogen gas or a mixture of gasses flows along a path indicated by the arrow 103 through a fuel cavity 120. The fuel enters the body member 102 in the downstream chamber 112. The fuel flows radialy outward from the center of the down stream chamber 112 and into the upstream chamber 110. The fuel enters the inlets 116 and flows into the mixing tubes 114. The fuel and air mix in the mixing tubes 114 and are emitted as a fuel-air mixture from the mixing tubes into a combustor portion 122 of a turbine engine. The fuel-air mixture combusts in the flame regions 124 of the combustor portion 122.

[0012] Previous injectors did not transfer thermal energy away from the fuel-air mixture sufficiently to prevent the fuel-air mixture from igniting or burning inside the mixing tubes 114 during certain harsh conditions. An ignition of the fuel-air mixture in the mixing tubes 114 may severely damage the injector 100.

[0013] FIG. 2 illustrates a side cut-away view of a portion of the injector 100, and will further illustrate the operation of the injector 100. The fuel flow is shown by the arrows 103. The fuel enters the downstream chamber 112 along a path parallel to the center axis 201 of the injector 100. When the fuel enters the downstream chamber 112, the fuel flows radialy outward from the center axis 201. The fuel flows into the upstream chamber 110 after passing an outer lip of the baffle member 108. The fuel flows through the upstream chamber 110, enters the inlets 116, and flows into the mixing tubes 114. The fuel-air mix is created in the mixing tubes 114, downstream from the inlets 116. The fuel is cooler than the air. The flow of the fuel around the surface of the mixing tubes 114 in the downstream chamber 112 cools the mixing tubes 114 and helps to prevent the ignition or sustained burning of the fuel-air mixture inside the mixing tubes 114.

[0014] To effectively cool the mixing tubes 114, the velocity of the fuel flow is maintained above a threshold level. As the fuel flow extends radialy outward in the downstream chamber 112, the surface area of the downstream wall 106 increases. Since the velocity of the fuel flow is influenced by the volume of the downstream chamber 112, the baffle member 108 that is disposed at an oblique angle to the down stream wall 106, the volume of the chamber increases as the fuel flow approaches the outer diameter of the downstream chamber 112-reducing the velocity of the fuel flow. The baffle member 108 is shown at an angle (Φ) relative to the downstream wall 106. The angle (Φ) of the baffle member 108 reduces the distance between the baffle member 108 and the downstream wall 106 (indicated by arrow 203) as the fuel flows radialy outward in the downstream chamber 112. The reduction of the distance 203 in proportion to the increase in the surface area of the downstream wall 106 allows the volume of the downstream chamber 112 to be maintained below a threshold volume. Once a volume for the down stream chamber is determined, the angle (Φ) of the baffle member 108 may be geometrically calculated to effectively maintain the lower threshold velocity of the gas flow. The angle of the baffle member 108 also reduces the distance between the baffle member 108 and the upstream wall 104 as the fuel flows into the upstream chamber 110. The angle of the baffle member 108 helps to maintain a uniform pressure and velocity of the fuel flow in the upstream chamber 110.

[0015] FIG. 3 illustrates a perspective, partially cutaway view of a portion of the injector 100. The heat exchange between the fuel and the outer surface of the mixing tubes 114 may be improved by cooling features disposed on the outer surface of the mixing tubes 114. FIG. 3 shows an exemplary embodiment of cooling fins 302 connected to the mixing tubes 114. The cooling fins 302 increase the surface area of the outer surface of the mixing tubes 114 and improve the heat exchange between the fuel and the outer surface of the mixing tubes 114. The additional surface area, and/or a higher heat transfer coefficient effect the improvement in the heat exchange. FIG. 3 is an example of one embodiment of cooling features. Other embodiments may include, for example, a different number of cooling fins, dimples, ridges, fins at oblique angles, groves, channels, or other similar cooling features.

Claims

1. A fuel injection nozzle (100) comprising:

a body member (102) having an upstream wall (104) opposing a downstream wall (106);

a baffle member (108) disposed in the body member (102) having an upstream surface and a downstream surface;

a first chamber (112) partially defined by the downstream surface of the baffle member (108) and an inner surface of the downstream wall (106);

a second chamber (110) communicative with the first chamber (112), partially defined by the upstream surface of the baffle member (108) and an inner surface of the upstream wall (104);

a fuel inlet communicative with the first chamber (112) operative to emit a fuel gas into the first chamber (112); and

a plurality of mixing tubes (114), each of the mixing tubes (114) having a tube inner surface, a tube outer surface, a first inlet (116) communicative with an aperture in the upstream wall operative to receive a second gas, a second inlet communicative with the tube outer surface and the tube inner surface operative to translate the fuel gas from the second chamber (110) into the mixing tube, a mixing portion operative to mix the fuel gas and the second gas, and an outlet

communicative with an aperture in the downstream wall operative to emit the mixed fuel and second gases; and **characterized in that**
the nozzle defines a fuel flow path defined by the fuel inlet, the first chamber (112), the second chamber (110), and the second inlet.

2. The fuel injection nozzle of claim 1, wherein each mixing tube (114) defines an air flow path.

3. The fuel injection nozzle of claims 1 or 2, wherein the body member (102) is tubular having a centered longitudinal axis parallel to the flow of the second gas.

4. The fuel injection nozzle of any preceding claim, wherein the baffle member (108) disposed in the body member (102) at an oblique angle to the downstream wall (106).

5. The fuel injection nozzle of any preceding claim, wherein each mixing tube (114) includes an upstream portion defined by the second chamber (110) and a downstream portion defined by the first chamber (112).

6. The fuel injection nozzle of claim 5, wherein the second inlet is disposed in the upstream portion of each mixing tube.

7. The fuel injection nozzle of any preceding claim, wherein each tube outer surface includes a heat transfer feature (302) disposed in the downstream portion of each mixing tube (114).

Patentansprüche

1. Kraftstoffeinspritzdüse (100), Folgendes umfassend:

ein Körperelement (102) mit einer stromaufwärtigen Wand (104), die einer stromabwärtigen Wand (106) gegenüber angeordnet ist;
ein Zwischenwandelement (108), das in dem Körperelement (102) angeordnet ist und eine stromaufwärtige Oberfläche und eine stromabwärtige Oberfläche aufweist;
eine erste Kammer (112), die teilweise durch die stromabwärtige Oberfläche des Zwischenwandelements (108) und durch eine innere Oberfläche der stromabwärtigen Wand (106) definiert ist;
eine zweite Kammer (110), in Kommunikation mit der ersten Kammer (112), teilweise definiert durch die stromaufwärtige Oberfläche des Zwischenwandelements (108) und eine innere Oberfläche der stromaufwärtigen Wand (104);
einen Kraftstoffeinlass, in Kommunikation mit der ersten Kammer (112), betriebsfähig, ein Kraftstoffgas in die erste Kammer (112) auszugeben; und
mehrere Mischröhren (114), wobei jede der Mischröhren (114) Folgendes aufweist: eine innere Röhrenoberfläche, eine äußere Röhrenoberfläche, einen ersten Einlass (116), der mit einer Öffnung in der stromaufwärtigen Wand kommuniziert, betriebsfähig, ein zweites Gas zu empfangen, einen zweiten Einlass, der mit der äußeren Röhrenoberfläche und der inneren Röhrenoberfläche kommuniziert, betriebsfähig, das Kraftstoffgas von der zweiten Kammer (110) in die Mischröhre zu leiten, einen Mischabschnitt, betriebsfähig, das Kraftstoffgas und das zweite Gas zu mischen, und einen Auslass, der mit einer Öffnung in der stromabwärtigen Wand kommuniziert, betriebsfähig, das Gemisch aus Kraftstoffgas und zweitem Gas auszugeben;
und **dadurch gekennzeichnet, dass**
die Düse einen Strömungspfad definiert, der durch den Kraftstoffeinlass, die erste Kammer (112), die zweite Kammer (110) und den zweiten Einlass definiert ist.

2. Kraftstoffeinspritzdüse nach Anspruch 1, wobei jede Mischröhre (114) einen Luftstrompfad definiert.

3. Kraftstoffeinspritzdüse nach Anspruch 1 oder 2, wobei das Körperelement (102) röhrenförmig ist und eine mittige Längsachse aufweist, die parallel zum Strom des zweiten Gases verläuft.

4. Kraftstoffeinspritzdüse nach einem der vorhergehenden Ansprüche, wobei das Zwischenwandelement (108) in einem zur stromabwärtigen Wand (106) schrägen Winkel im Körperelement (102) angeordnet ist.

5. Kraftstoffeinspritzdüse nach einem der vorhergehenden Ansprüche, wobei jede Mischröhre (114) einen durch die zweite Kammer (110) definierten stromaufwärtigen Abschnitt und einen durch die erste Kammer (112) definierten stromabwärtigen Abschnitt aufweist.

6. Kraftstoffeinspritzdüse nach Anspruch 5, wobei der zweite Einlass im stromaufwärtigen Abschnitt einer jeden Mischröhre angeordnet ist.

7. Kraftstoffeinspritzdüse nach einem der vorhergehenden Ansprüche, wobei jede Röhrenaußenoberfläche ein Wärmeübertragungsmerkmal (302) aufweist, das im stromabwärtigen Abschnitt einer jeden Mischröhre (114) angeordnet ist.

Revendications

1. Buse d'injection de combustible (100) comprenant :

   un élément de corps (102) ayant une paroi amont (104) opposée à une paroi aval (106) ;
   un élément de chicane (108) disposé dans l'élément de corps (102) ayant une surface amont et une surface aval ;
   une première chambre (112) partiellement définie par la surface aval de l'élément de chicane (108) et une surface interne de la paroi aval (106) ;
   une seconde chambre (110) communiquant avec la première chambre (112), partiellement définie par la surface amont de l'élément de chicane (108) et une surface interne de la paroi amont (104) ;
   une entrée de combustible communiquant avec la première chambre (112) et qui est à même d'émettre un gaz combustible dans la première chambre (112) ; et
   une pluralité de tubes de mélange (114), chacun des tubes de mélange (114) ayant une surface de tube interne, une surface de tube externe, une première entrée (116) communiquant avec une ouverture de la paroi amont qui est à même de recevoir un second gaz, une seconde entrée communiquant avec la surface de tube externe et la surface de tube interne et qui est à même de transférer le gaz combustible de la seconde chambre (110) dans le tube de mélange, une partie de mélange qui est à même de mélanger le gaz combustible et le second gaz, et une sortie communiquant avec une ouverture de la paroi aval qui est à même d'émettre le mélange de gaz combustible et de second gaz ; et **caractérisée en ce que** :
   la buse définit un trajet d'écoulement de combustible défini par l'entrée de combustible, la première chambre (112), la seconde chambre (110) et la seconde entrée.

2. Buse d'injection de combustible selon la revendication 1, dans laquelle chaque tube de mélange (114) définit un trajet d'écoulement d'air.

3. Buse d'injection de combustible selon la revendication 1 ou la revendication 2, dans laquelle l'élément de corps (102) est tubulaire avec un axe longitudinal centré parallèle à l'écoulement du second gaz.

4. Buse d'injection de combustible selon l'une quelconque des revendications précédentes, dans laquelle l'élément de chicane (108) est disposé dans l'élément de corps (102) en formant un angle oblique avec la paroi aval (106).

5. Buse d'injection de combustible selon l'une quelconque des revendications précédentes, dans laquelle chaque tube de mélange (114) comprend une partie amont définie par la seconde chambre (110) et une partie aval définie par la première chambre (112).

6. Buse d'injection de combustible selon la revendication 5, dans laquelle la seconde entrée est disposée dans la partie amont de chaque tube de mélange.

7. Buse d'injection de combustible selon l'une quelconque des revendications précédentes, dans laquelle chaque surface de tube externe comprend une caractéristique de transfert de chaleur (302) disposée dans la partie aval de chaque tube de mélange (114).

FIG. 1

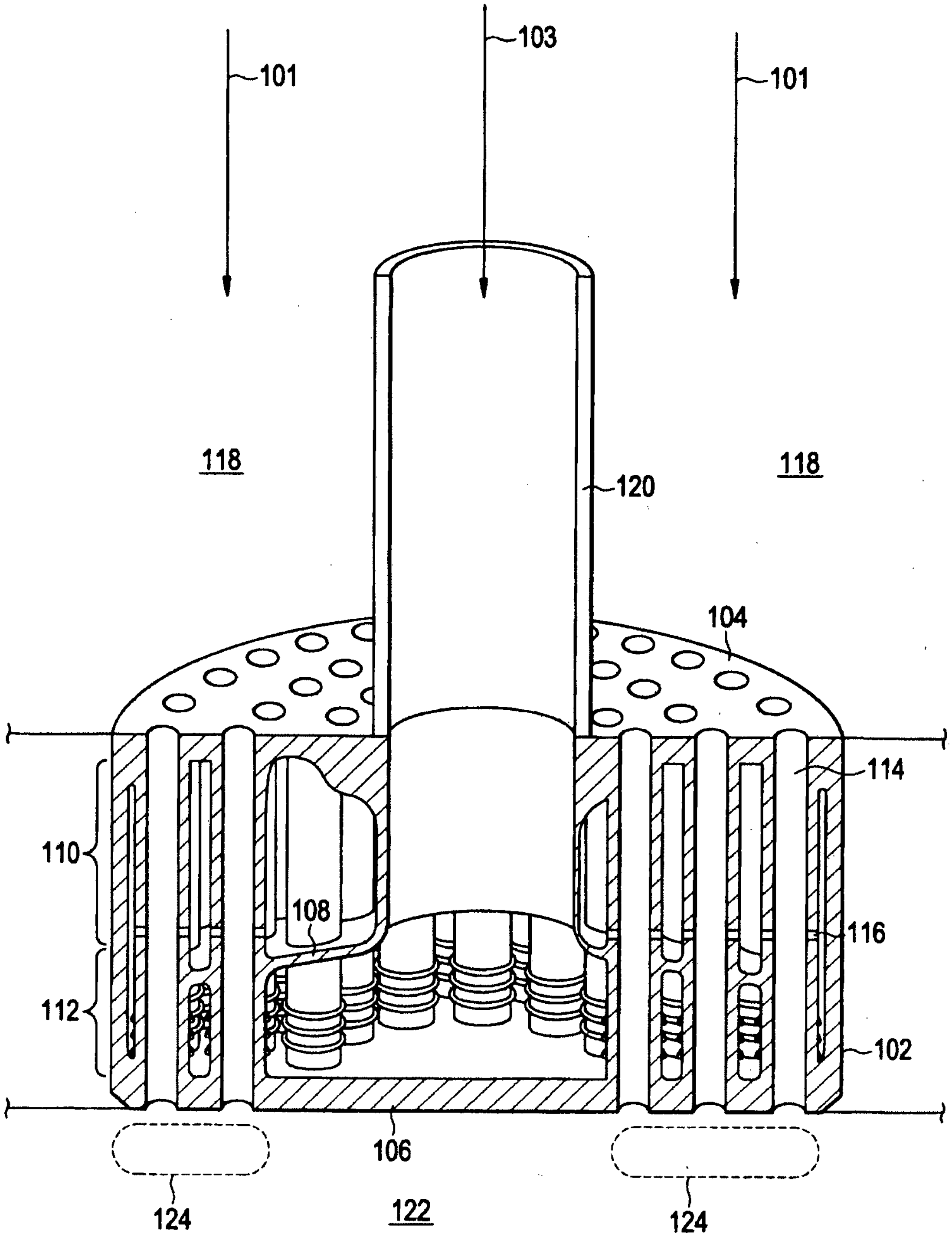

101
103
101
118
120
118
104
114
110
108
116
112
102
106
124
122
124

FIG. 2

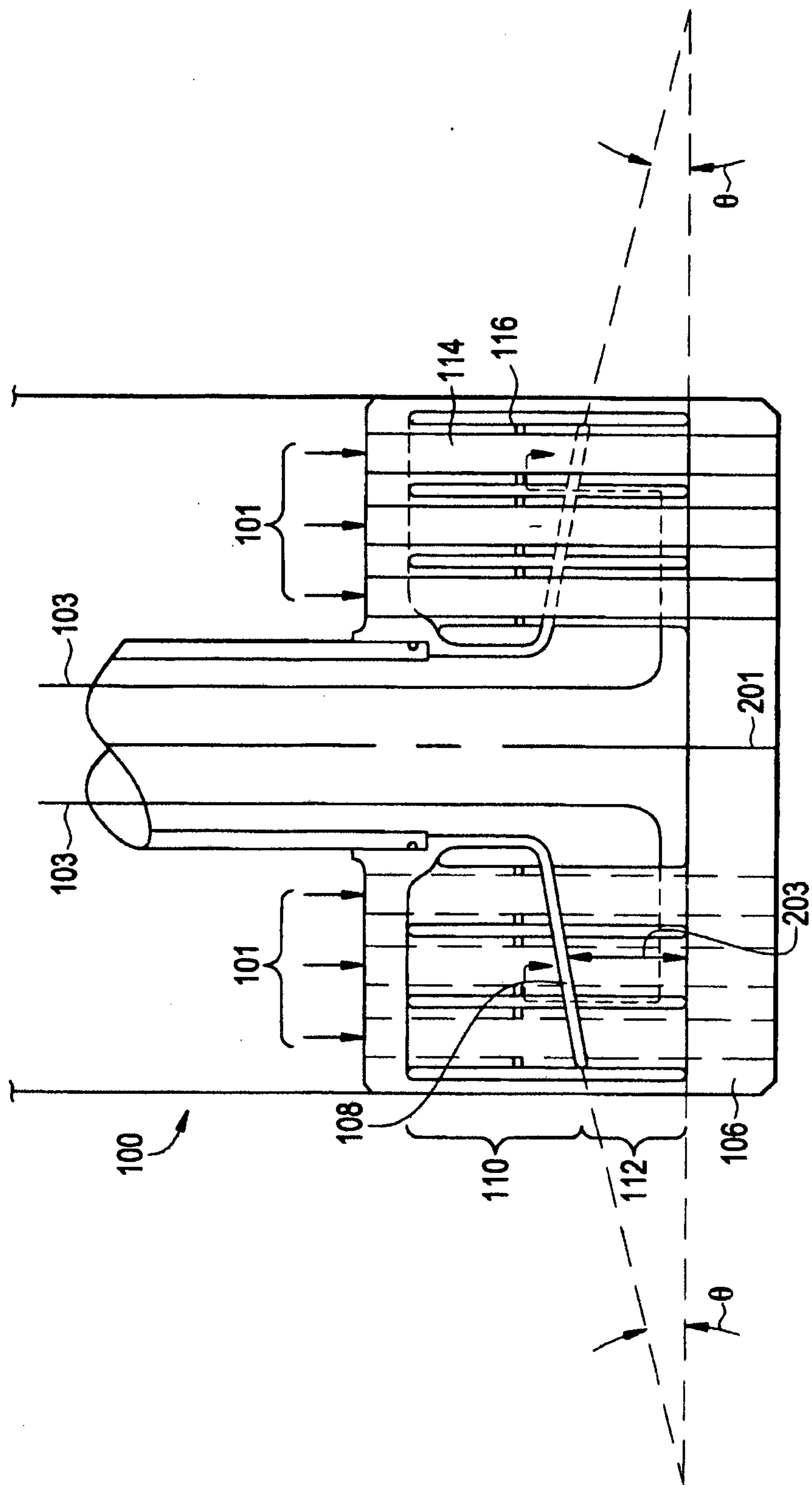
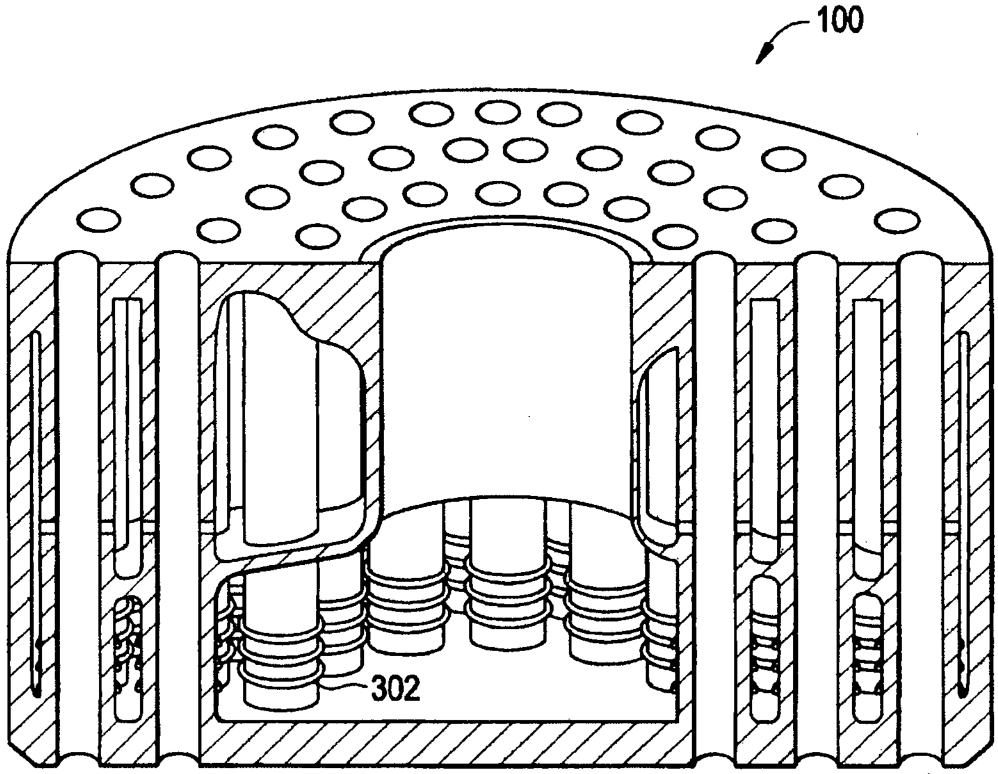


FIG. 3



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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